UNIVERSITY OF MARYLAND

Integrated Energy Systems at the University of Maryland

April, 2002

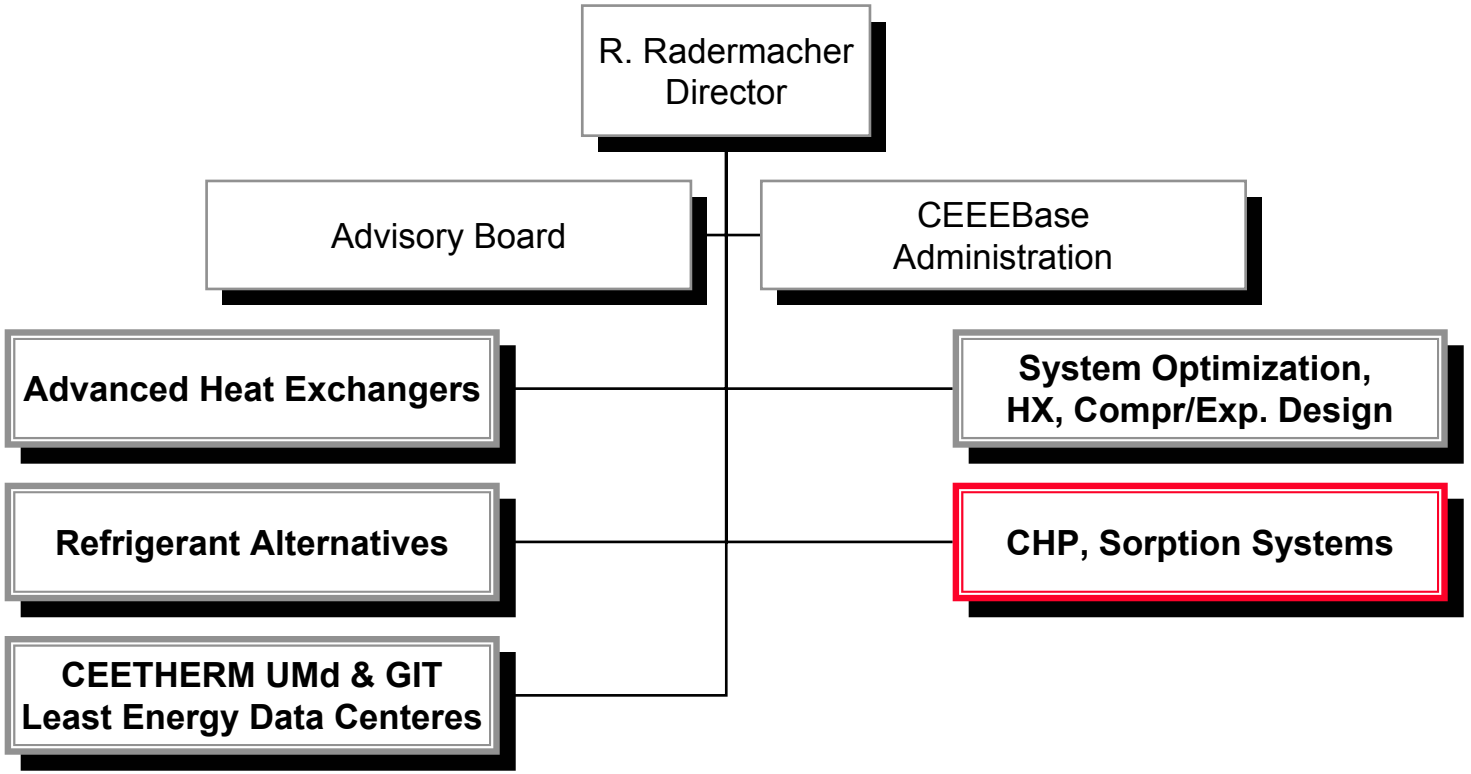
Aris Marantan, Matthew Cowie, Lucia Liao

Reinhard Radermacher

CHP
For Buildings

CEEE
Center for Environmental Energy Engineering

CEEE Organization



Objective

- Investigate Integration Issues of CHP Components into Systems
- Demonstrate Performance Potential
- Address Research Needs as they are Presented by Consortium Sponsors (not DOE funded, but grew out of this project)
  - Modeling and Optimization
  - Diagnosticians

Integration Test Center Building

- TYPICAL, MEDIUM SIZE OFFICE BUILDING, 51,000 FT^{2,}
- 4 FLOORS, 2 ZONES
- 90-TON ROOF TOP UNIT FOR EACH ZONE
- COOLING ALL YEAR
- ECONOMIZER CYCLE
- VAV WITH ELECTRIC REHEAT
- LOW LEVEL CONTROLS
- GAS RARELY USED
- ELECTRIC ~300 kW PEAK
- 10 YEARS OLD, 200 OCCUPANTS

HP VEE - DAQ40.vee

File Edit View Debug Flow Device I/O Data Display Window Help

Main

Start

Time of Last Reading: Wed 28/Feb/2001 1:00:37 PM

Microturbine Efficiency (%): 24.21

* Estimate (as of 2/27/01)

Damp1: 0: 4.446m

Damp2: 0: 3.894m

Delay: 0

Interval: 60

..\..\DATA\HP VEE\022811.dat

Total Accumulated Actual Savings (kW-hr) *: -237.84

Total Accumulated Potential Savings (kW-hr) *: 1285.05

Total Accumulated Actual Savings ($) *: $ -3.44

Total Accumulated Potential Savings ($) *: $ 25.88

CO2 (ppm)

R1 S.A.	R1 R.A.	R2 S.A.	R2 R.A.
0: 410.9	0: 480.4	0: 489.5	0: 529

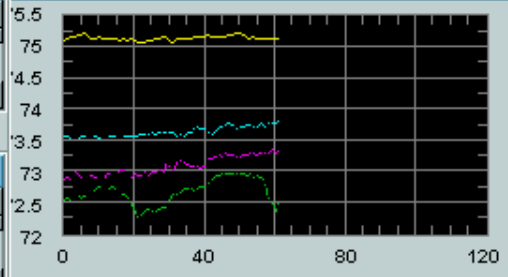
Temperature (F)

R1 SA	R1 R.A.	R1 M.A.	Space...
50.99	71.11	-13	00: 74.92
R2 SA	R2 R.A.	R2 M.A.	01: 73.99
59.11	72.19	54.93	02: 76.51

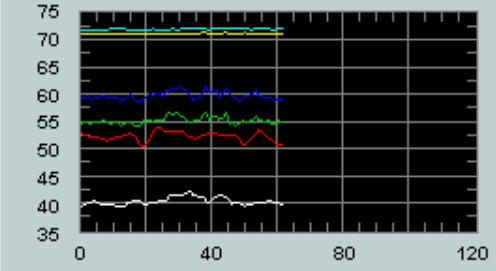
Relative Humidity (RH)

R1 S.A.	R1 R.A.	R1 M.A.	Space...
19.46	12.93	264.1	00: 12.69
R2 S.A.	R2 R.A.	R2 M.A.	01: 14.26
16.75	12.29	27.18	02: 13.97

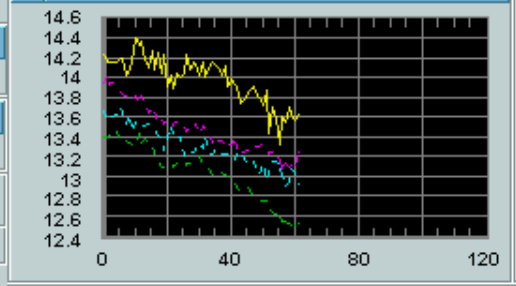
4-Hour Space Temperature History (F)



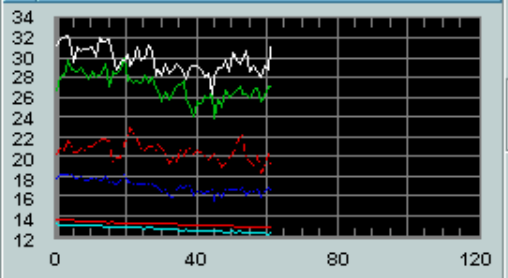
4-Hour RTU Temp History (F)



4-Hour Space RH History (%)



4-Hour RTU RH History (%)



Gas line

Flow Rate (CFM)	Temp(deg. F)	Pressure (psig)
0: 566.6E36	0: 2.944E39	0: 113.5E36

SRI Testing

Comp. ...	RH (%)	P (psia)
2.379	0: 122.6	0: 495E36

Temp (C): 0: -1.228E39

\SRI-DATA\SRI-022811.dat

RI-DATA\SRI-Press022811.

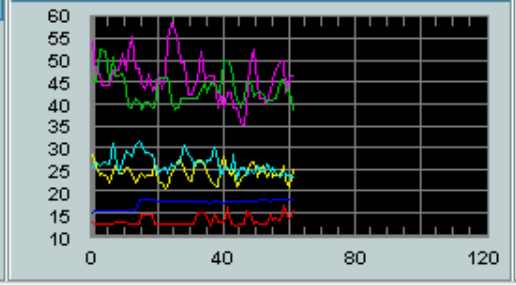
Power (kW)

T1	HP1&2	RTU1
15	27.8	9.26
25.28	46.7	15.56
T2	HP3&4	RTU2
14	23.2	10.7
23.5	39.03	18.04
Total	kW	V
168.1	0: 103.8	0: 1.04

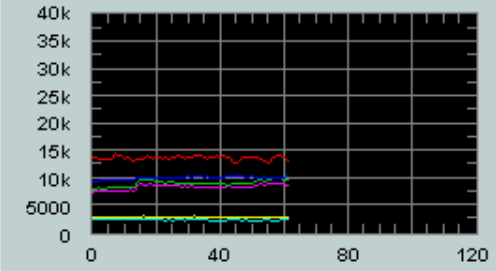
Airflow

CFM
0: 2866
1: 2324
2: 8634
3: 9525
4: 12.98k
5: 10.25k

4-Hour Power History (kW)



4-Hour Flow Rate History (CFM)



VAV	H	F	RTU1	RTU2
1			EF	
2			C1	
3			C2	
4			HG1	46.5	84.8
5			HG2	48.9	41.9
6			L1	
7			L2	
8			SF1	5.4	8.8
9			SF2	4.6	7.2
10				
11				

Natural Gas

ft.^3 /int.

0: 15

1: 0

2: 0

Bldg Press

Z1...	Z2...
-0.067	0.019

Weather Station

OA F	OA RH %	CO2...
39.99	31	-500

Solar W/m^2: Sunny 709

Wind Speed mph: 9.9

Press...	Wind Direction deg
29.82	314

Ready

STD PROF MOD WEB

Start BASLin... HP... PE... DA... LO... VIS... IT... Ex... 1:01 PM

Edit View Favorites Tools Help

Back Search Favorites Media

http://www.enme.umd.edu/ceee/bchp/ Go

Cooling Heating and Power

CHP Home | About CHP | Consortium | Technology | Tech Transfer
CEEE Home | CHP Team | Directions | Links | Publications
Search

Integrated Energy Systems

Discover the world of Integrated Energy Systems.

CHP Virtual Tour

Take a virtual tour of the Integration Test Center at the University of Maryland's Chesapeake Building !

Data Acquisition System

View the current conditions at the Chesapeake Building.

Control and Monitoring

Try an interactive demonstration.
username: guest
password: user

CHP Test Center

- The **Integrated Energy Systems Test Center** is designed as a research facility that explores the intricacies of integrating advanced power generating equipment, such as microturbines and fuel cells, with waste heat activated technologies such as absorption chillers and desiccant systems.
- The **Chesapeake Building**, which currently has two CHP systems installed, is a fully instrumented platform for conducting research on advanced energy efficient and environmentally friendly building technology.

CHP System 2

What's New

- Chinese Delegation Visit the CHP Integration Test Center on March 26, 2002.
- British Parliament Members Visit the CHP Integration Test Center on January 30, 2002.
- The recent Microturbine Applications Workshop was held at the University of Maryland Inn and Conference Center on January 17-18, 2002.
- The Sem-Annual CHP Consortium meeting was held in Atlantic City on Jan. 12, 2002, from 3:00 pm to 6:00 pm.
- The CHP team welcomes the newest member !

[More Information...]

Edit View Favorites Tools Help

Back Search Favorites Media

http://www.enme.umd.edu/ceee/bchp/ Go

[Data Acquisition System](#)

View the current conditions at the Chesapeake Building.

[Control and Monitoring](#)

Try an interactive demonstration.
username: guest
password: user

[More Information...]

[Tech Briefs](#)

Browse the DOE Tech Briefs and Program Plans for CHP.

[CHP Guidebook](#)

View the Guidebook of the CHP Test Center.

What's New

- [Chinese Delegation](#) Visit the CHP Integration Test Center on March 26, 2002.
- [British Parliament Members](#) Visit the CHP Integration Test Center on January 30, 2002.
- The recent [Microturbine Applications Workshop](#) was held at the University of Maryland Inn and Conference Center on January 17-18, 2002.
- The Sem-Annual CHP Consortium meeting was held in Atlantic City on Jan. 12, 2002, from 3:00 pm to 6:00 pm.
- The CHP team welcomes the newest member !

[More Information...]

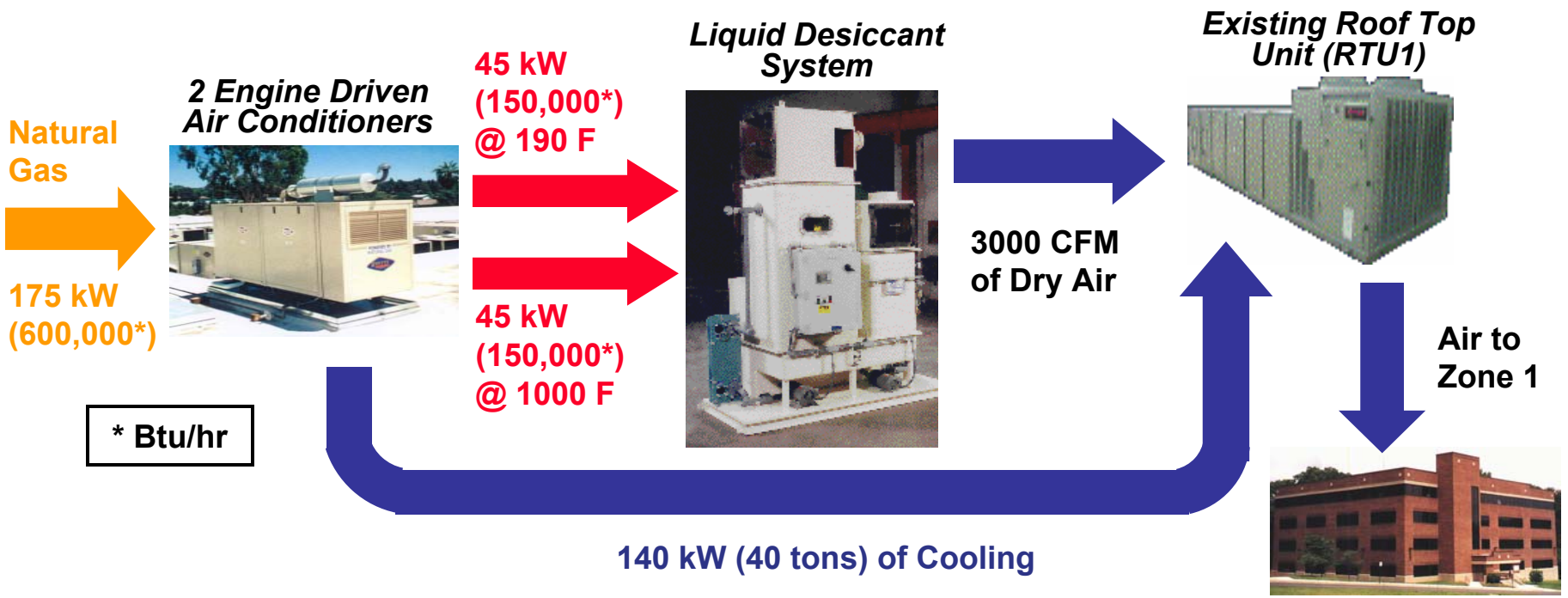
Events

- **February 28, 2002** - International District Energy Association (IDEA) annual conference in Denver, Colorado.
- **March 12, 2002** - DG & On-site Power Conference in Atlanta, GA.
- **May 2002** - iTHERM at the Georgia Institute of Technology.
- **June 22-26, 2000** - ASHRAE Summer Meeting, Symposium on CHP for Buildings in Honolulu, HI.
- **August 2002** - IHTC in Grenoble, France.
- **September 17 - 20, 2002** - 5th IIR-Gustav Lorentzen Conference on Natural Working Fluids will be held in Guangzhou, China.
- **September 24-27, 2002** - International Sorption Heat Pump Conference will be held in Shanghai, China.
- **October 9-11, 2002** - Association of Energy Engineers (AEE) 2002 Combined Heat & Power Expo / Cogeneration Congress in Atlanta, Georgia.
- **November 17-22, 2002** - American Society of Mechanical Engineers (ASME) - International Mechanical Engineering Congress and Exposition, New Orleans, LA.

[More Information...]

Center for Environmental Energy Engineering
University of Maryland, Department of Mechanical Engineering
College Park, MD 20742

CHP System 1



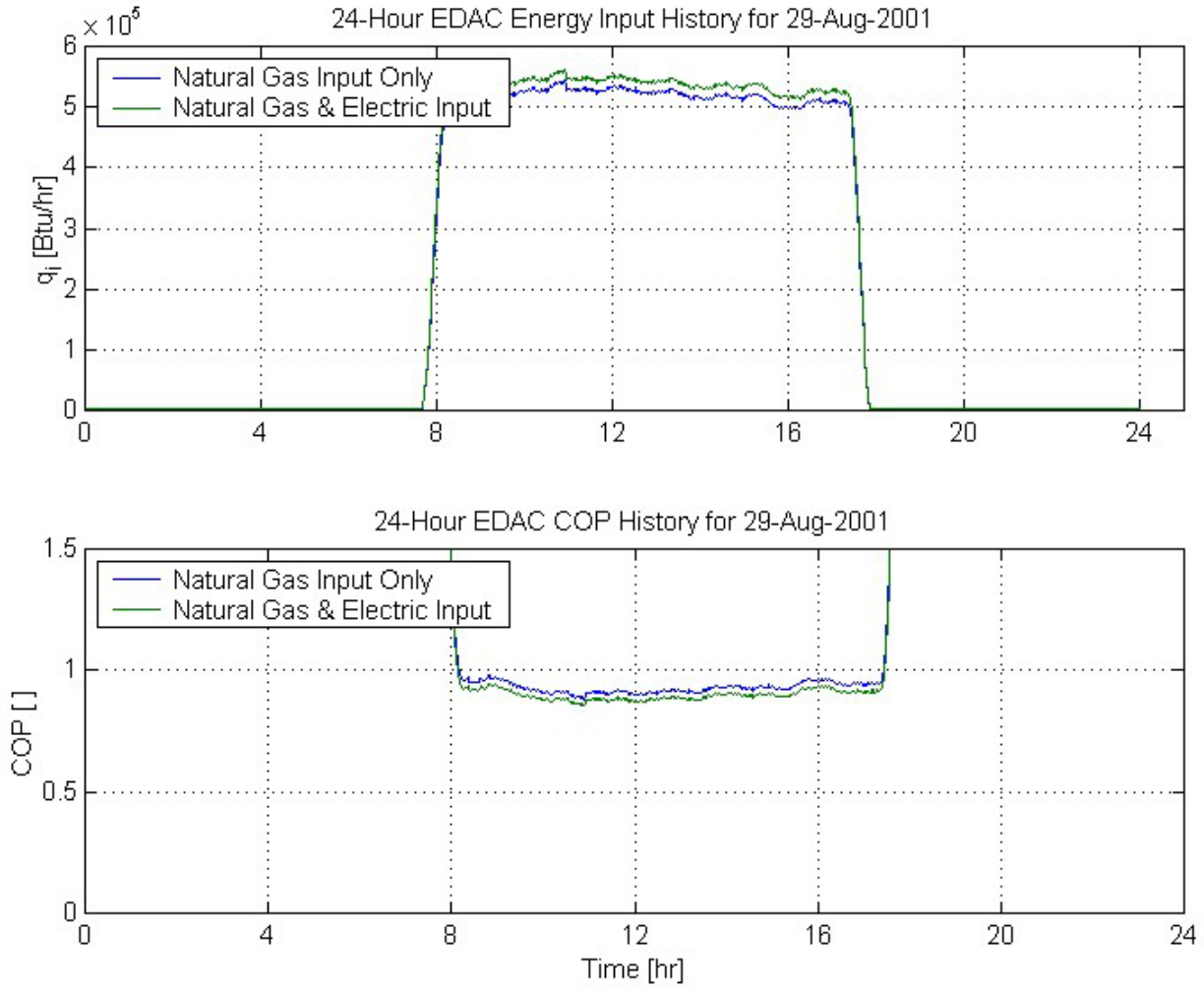
•Engine jacket water & exhaust used to regenerate desiccant

Engine Driven Heat Pumps

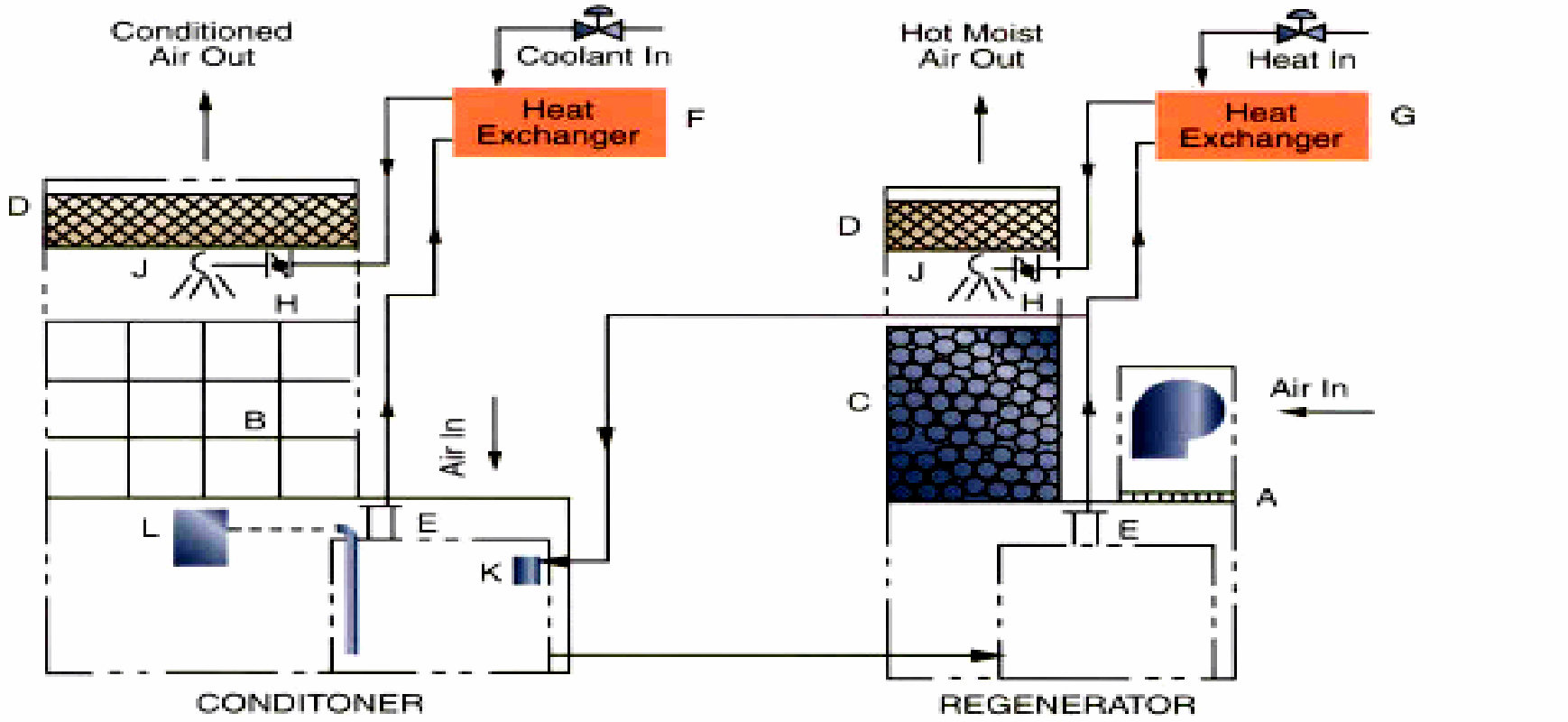
Capacity on air side, issues with air flow rate measurements

- Power Consumption @ rated capacity, 6.8 kW measured, 8.5 kW rated
  - 2 hp, Heat Recovery Pump, 1.5 kW
  - 2 Condenser (outdoor unit) rated 6 kW
  - 2 Engine section 1 kW
- Gas consumption measured 1,050,000 Btu/hr, 10.5 therms, 1050 CFH, should be less as gas pressure is 10” wc

Engine Driven Heat Pumps

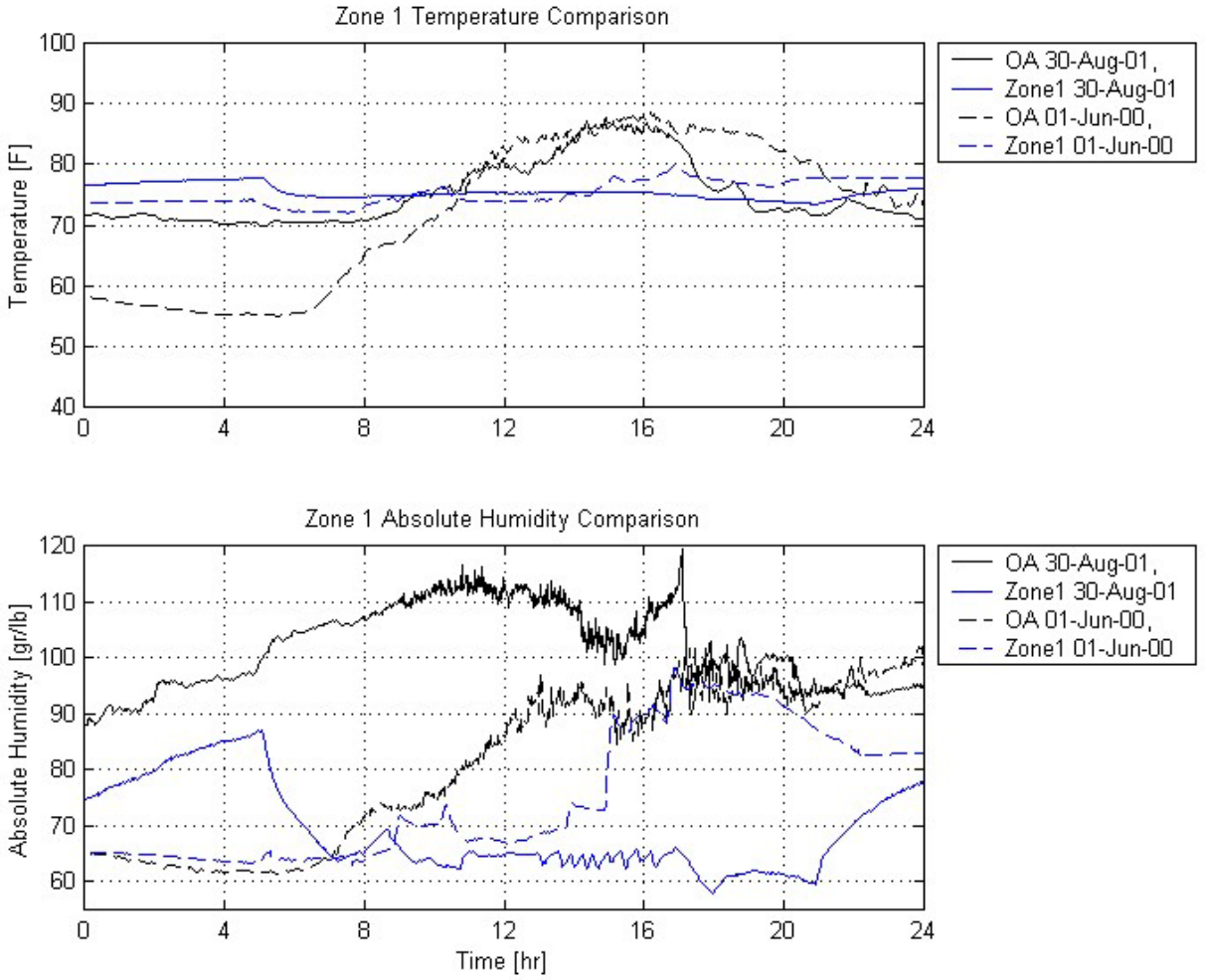


CHP System 1 Liquid Desiccant

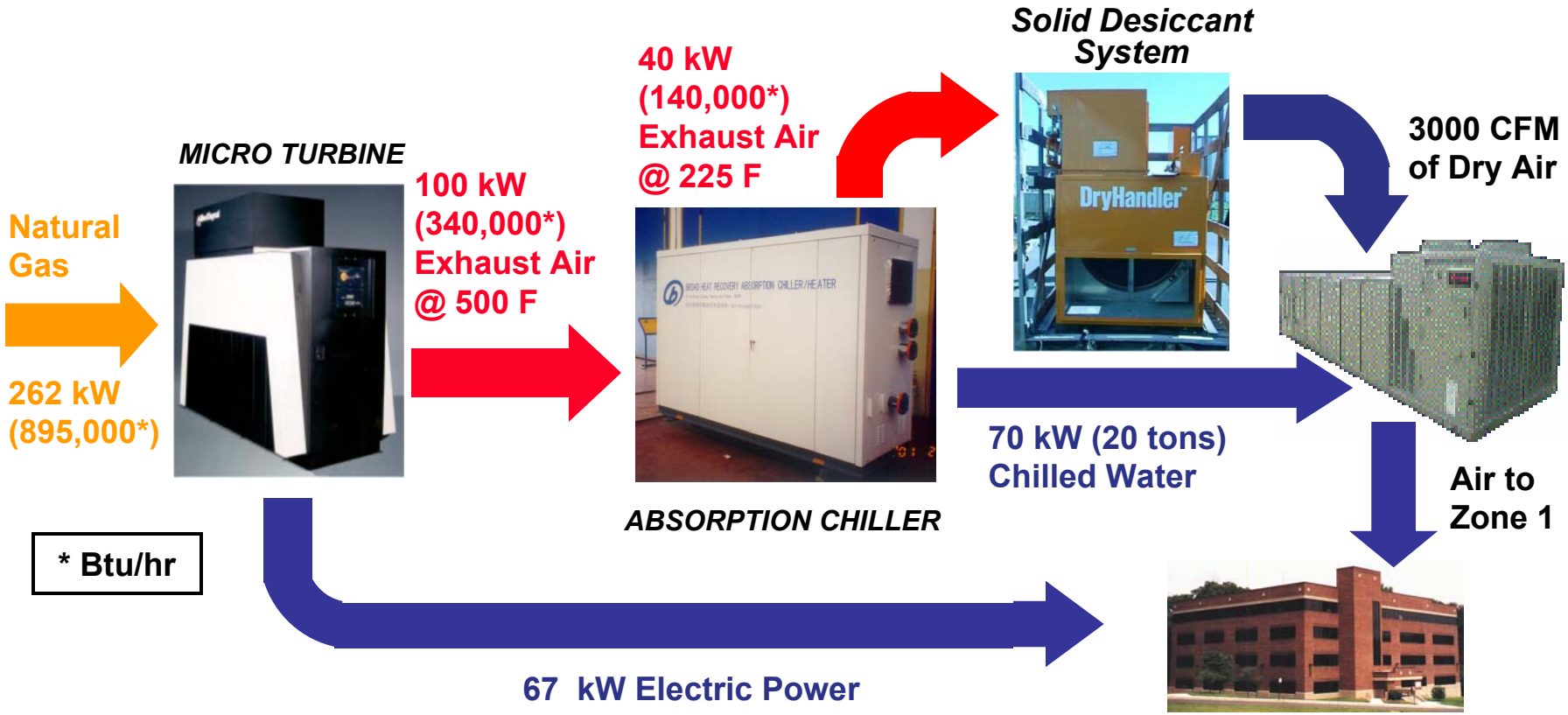


A Diffuser
B Packing Blocks
C Packing Spheres
D Mist Eliminators
E Kathene Pump
F Kathene Cooler
G Kathene Heater
H Flow Control Valve
J Kathene Flooding Nozzle
K Internal Kathene Flow Meter
L Modulating Level Controller

Comparison


Zone 1 Temperature Comparison
Temperature [F]
100
90
80
70
60
50
40
0
4
8
12
16
20
24
OA 30-Aug-01,
Zone1 30-Aug-01
OA 01-Jun-00,
Zone1 01-Jun-00
Zone 1 Absolute Humidity Comparison
Absolute Humidity [gr/lb]
120
110
100
90
80
70
60
Time [hr]
OA 30-Aug-01,
Zone1 30-Aug-01
OA 01-Jun-00,
Zone1 01-Jun-00

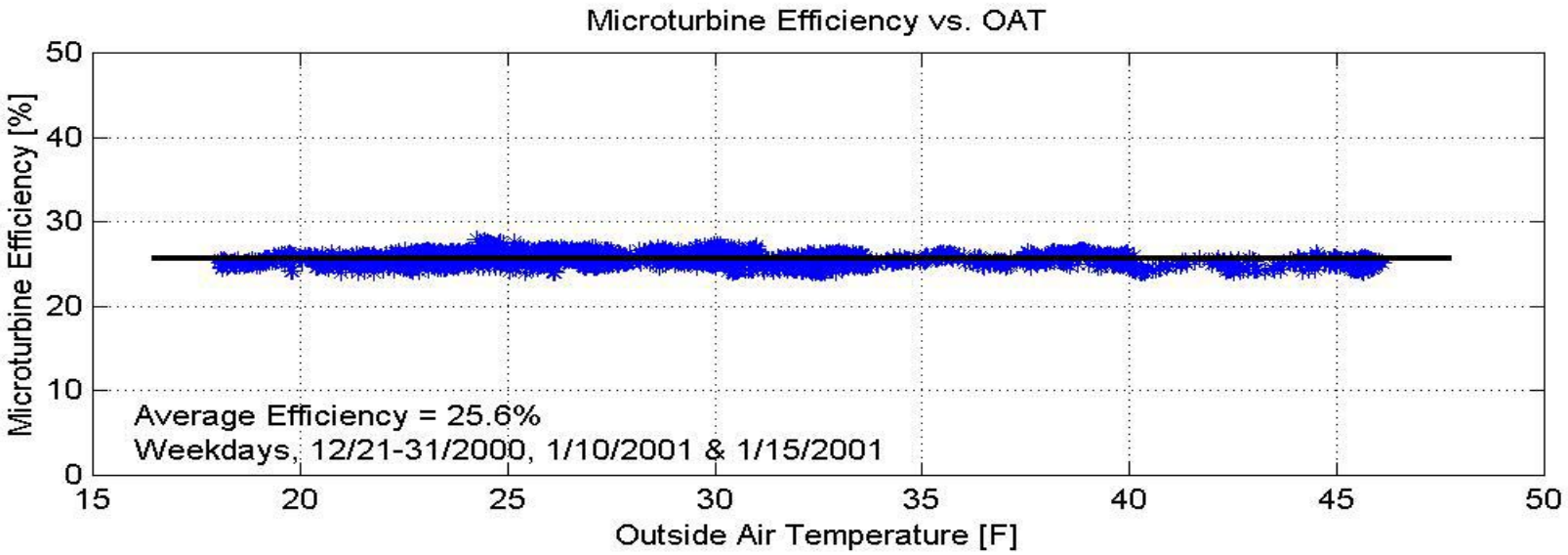
CHP System 2

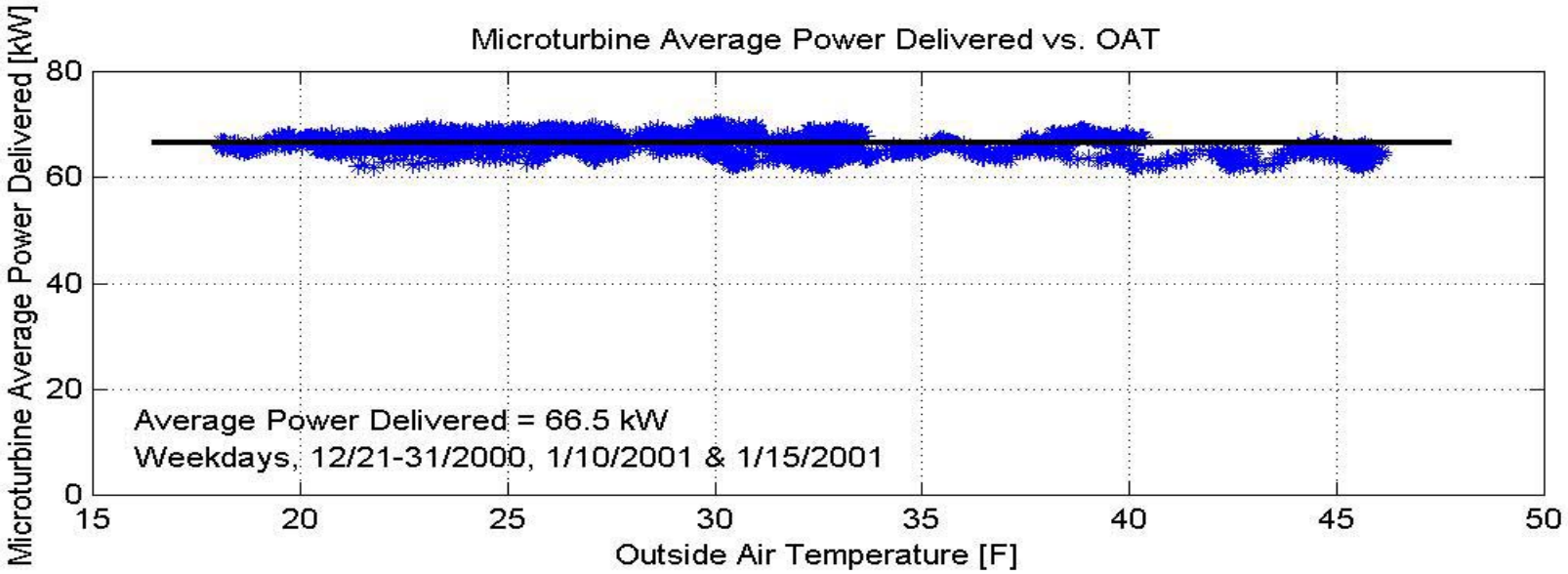


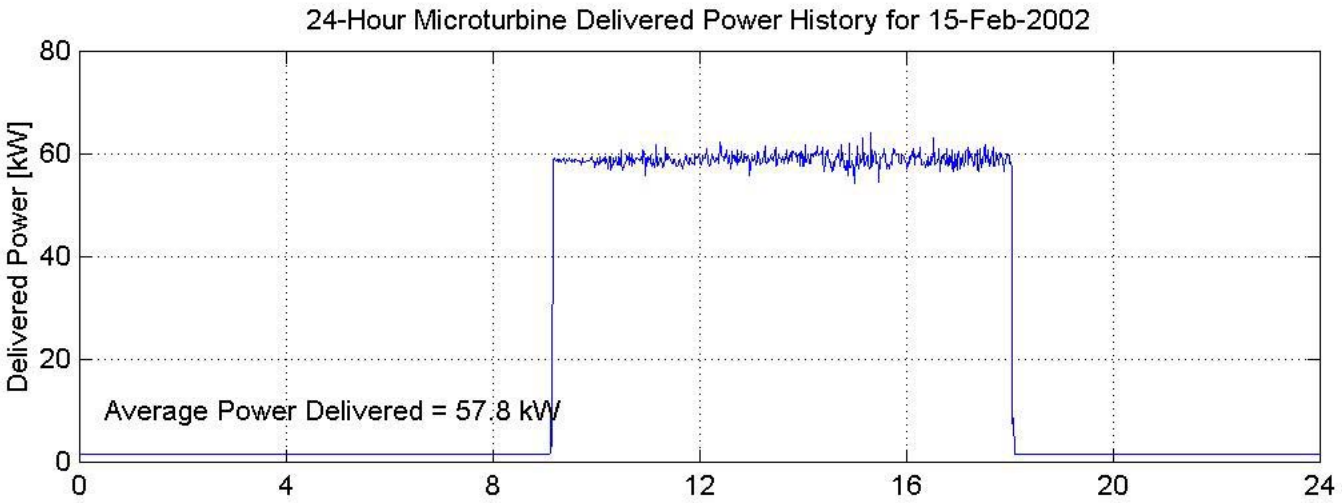
- Turbine efficiency 25.6 %, with chiller 63.5 %, and with desiccant 79.2%
- Single effect absorption chiller with COP of 0.7
- Supplemental cooling provided by existing RTU

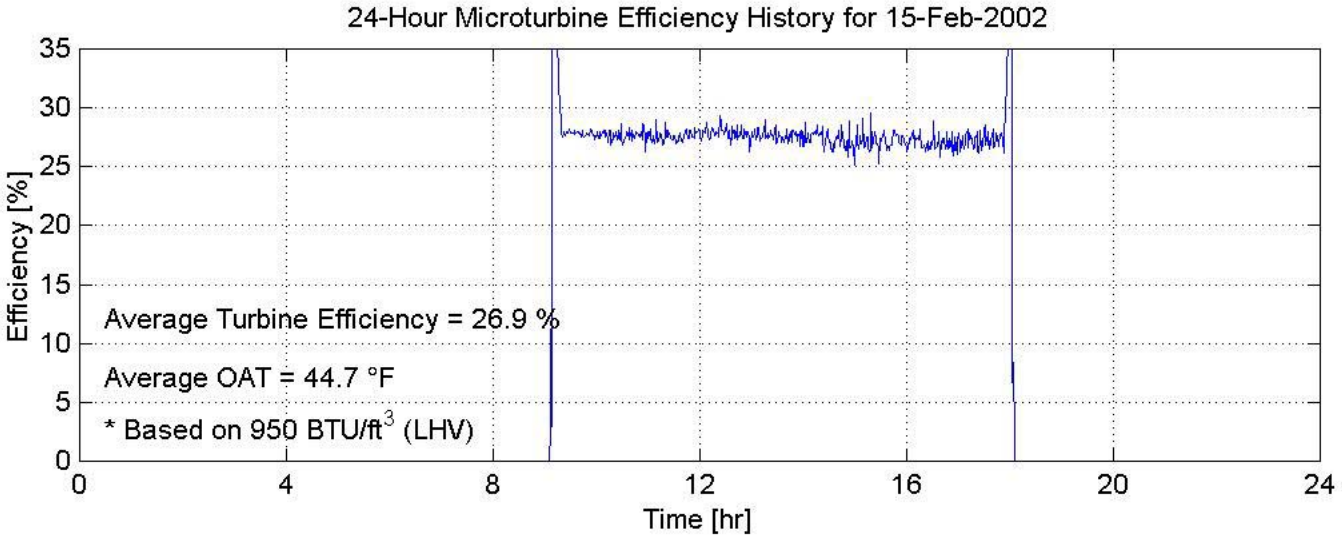

BROAD HEAT RECOVERY ABSORPTION CHILL

Microturbine Performance







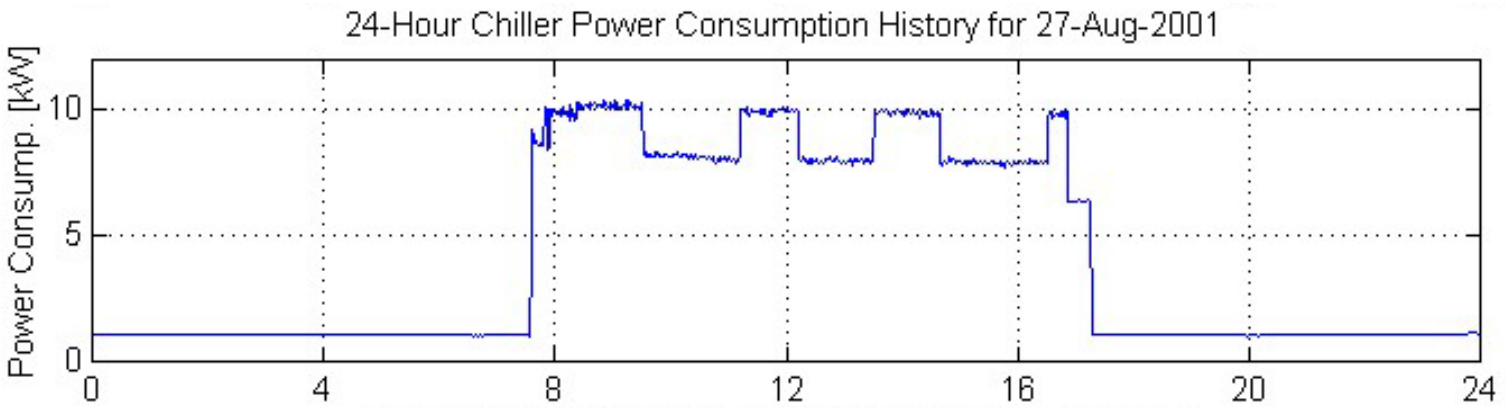


CHP
For Buildings

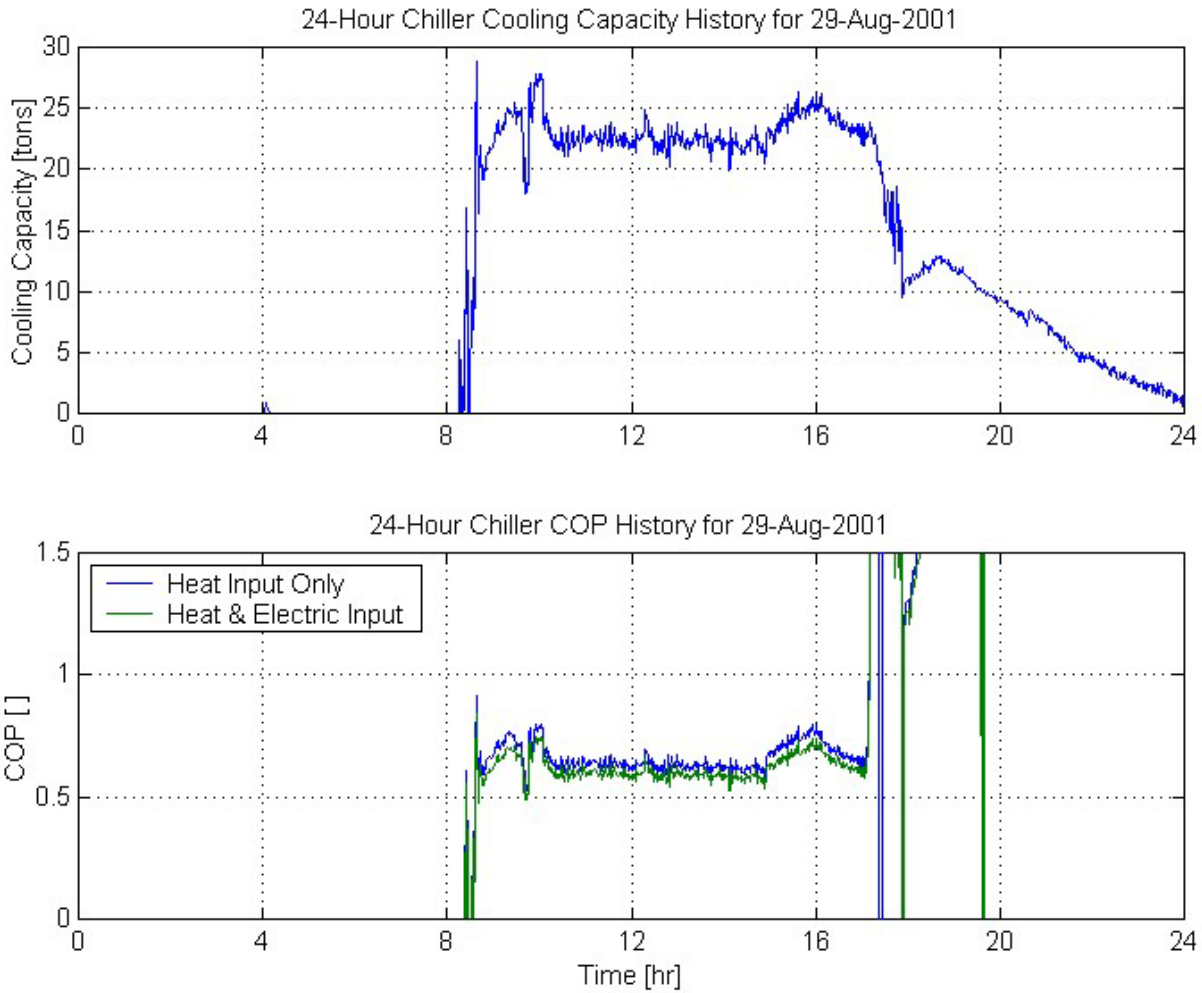
Center for Environmental Energy Engineering

Broad Absorption Chiller

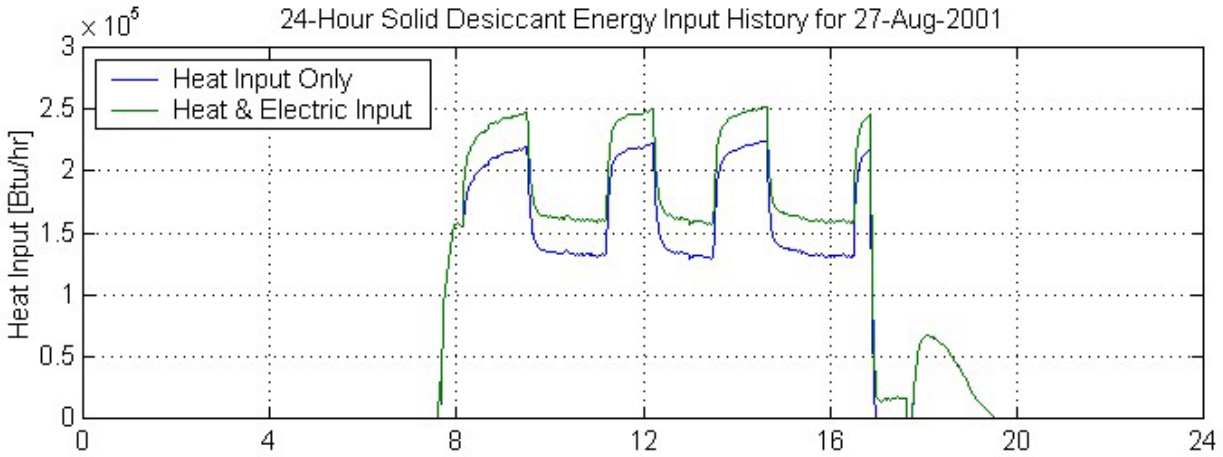
- Microturbine exhaust driven only
- 20-ton nominal capacity
- Single effect, COP = 0.7
- VFD fan drives exhaust through generator
- Microturbine power drives chiller & auxiliaries about 10 kW
  - Chilled water pump
  - Condenser water pump
  - Cooling tower
  - Exhaust fan
  - Solution and refrigerant pumps

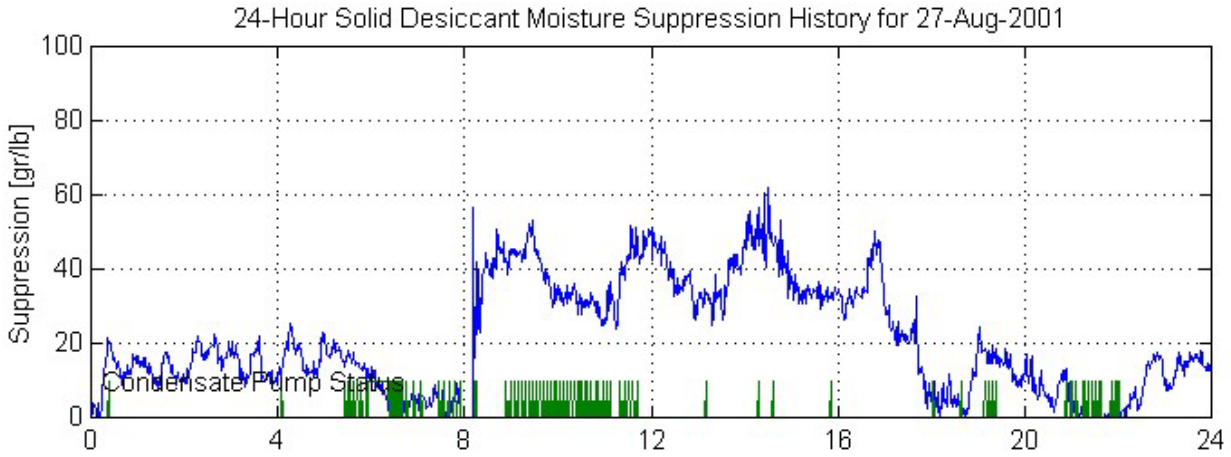


Absorption Chiller Data

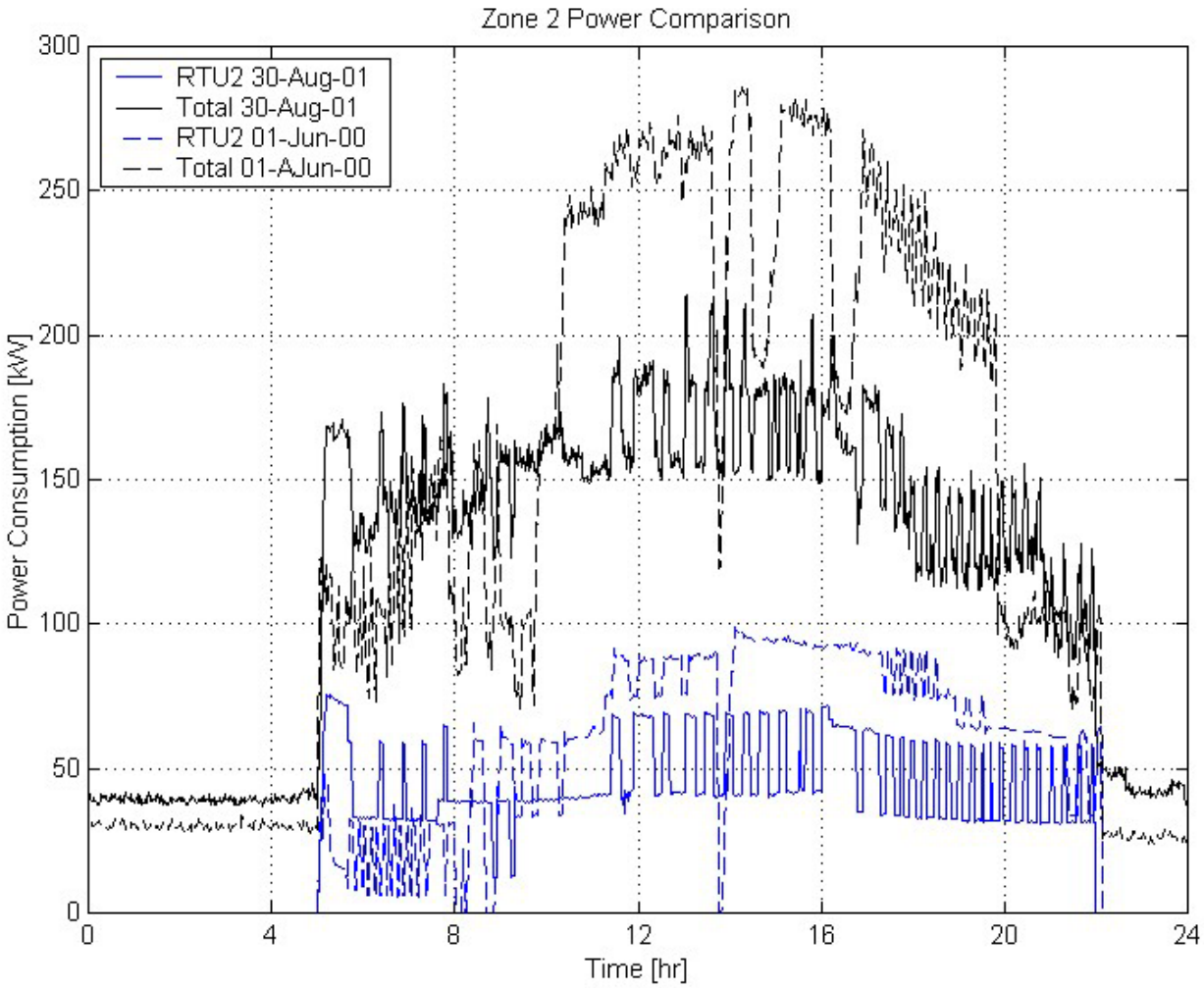


Solid Desiccant Performance





Comparison


Zone 2 Power Comparison
RTU2 30-Aug-01
Total 30-Aug-01
RTU2 01-Jun-00
Total 01-AJun-00
Power Consumption [kW]
Time [hr]
0
50
100
150
200
250
300
0
4
8
12
16
20
24

Primary Energy Savings

- Compared to existing equipment: 17%
- Compared to new equipment: 5-10%
- Goal for 2002 Cooling Season: as close to 30% as possible!
- Largest Challenge: Parasitic Power

Tree Site Page - Microsoft Internet Explorer

File Edit View Favorites Tools Help

Back Search Favorites History

Address http://129.2.32.252/stations/UofMdBCHP01/TREE/SiteTreeIE[1.htm

Links Yahoo! University of Maryland BCHP Homepage Data Acquisition System

- U of MD Chesapeake Hall
- Broad Chiller
- ATS Dessicant Unit
- Roof Top Unit 2
- Logs
- Log Archive
- Alarms
- Alerts

www.enme.umd.edu/ceee/bchp

Accomplishments

- Two Systems Installed and in Operation
- Education and Information Dissemination
  - Tours, Conferences
  - Workshops, 1 Graduate, 1 Undergrad. Course
- Improved Indoor Air Quality: Reduced Humidity, Other Aspects under Investigation
- Lowered Electric Power Consumption
- Primary Energy Savings
- Current/Future Work
  - Minimize parasitic loads
  - Controls Integration
  - Complete System Performance Analysis

Professional Collaboration

- ORNL – Sensors (CO_2 and Humidity)
- PNNL – Whole Building Diagnostician
- NREL – Liquid Desiccant Components
- Energy Storage (DOE, Energetics, NRECA, Sandia – Distributed Energy Technology Simulator)
- Southern Research Institute, EPA, Honeywell – Independent Verification of Micro-Turbine Performance and Emissions
- ORNL – Integrated System Performance Evaluation

Thanks !


UNIVERSITY OF
18
56
MARYLAND


CEEE
Center for Environmental Energy Engineering


DEPARTMENT OF ENERGY
UNITED STATES OF AMERICA

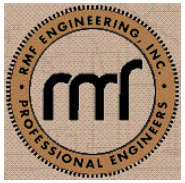

ornl
OAK RIDGE NATIONAL LABORATORY


DAIKIN


Honeywell


B.A.C.
Baltimore Aircoil


pepco


RMF ENGINEERING, INC.
rmf
PROFESSIONAL ENGINEERS


TRION


EPRI


Washington
Gas


ATS
Stulz Air Technology Systems, Inc.


Pacific Northwest
National Laboratory
Operated by Battelle for the
U.S. Department of Energy


EPA
United States
Environmental Protection Agency


TRIDIUM


BROAD AIR CONDITIONING
远大空调有限公司


CAPRON


GOETTL
AIR CONDITIONING


TRIGEN


KATHABAR®